DJI Phantom Drone Disassembly: An Electronics Analysis

Texas Instruments Electronics Online Challenge

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Table of Contents

Introduction

Context

The DJI Phantom drone was once a preeminent consumer drone that introduced GPS, autopilot algorithms, and intelligent orientation control into the consumer market. Despite its release in 2013, it remains a relic of the innovation that led to modern technologies; motion-tracking AI and copious other hallmarks of contemporary drones make the Phantom technologically inferior but conceptually the equivalent in terms of functionality.

Selection Process

I have held an innate fascination with quadcopters since initially witnessing the flight of the Phantom drone. The method of achieving a full range of motion via clever control of each motor is particularly engrossing to view. I thought the Phantom would be perfect for this project since it has been decommissioned from its use in professional photography and combines my interests in quadcopter flight and control systems.

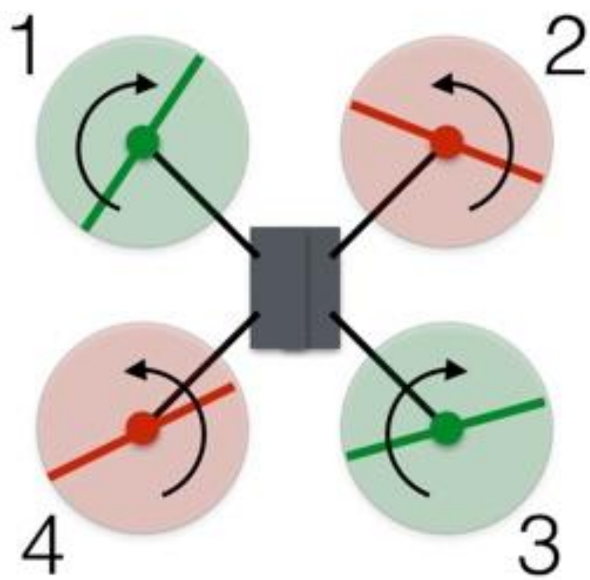


Figure 1. This shows the physics of quadcopter flight. By rotating two propellers in either direction, all 6 degrees of movement are possible.

Disassembly Method

Figure 2. *This is the constructed DJI Phantom 1 drone. It is a rigid-base quadcopter with four independent propellers for flight control.*

Figure 3. *I used various tools for the deconstruction process: a Phillips-head screwdriver, a 3/32" hex screwdriver, and pliers. There were several screw standards across the build.*

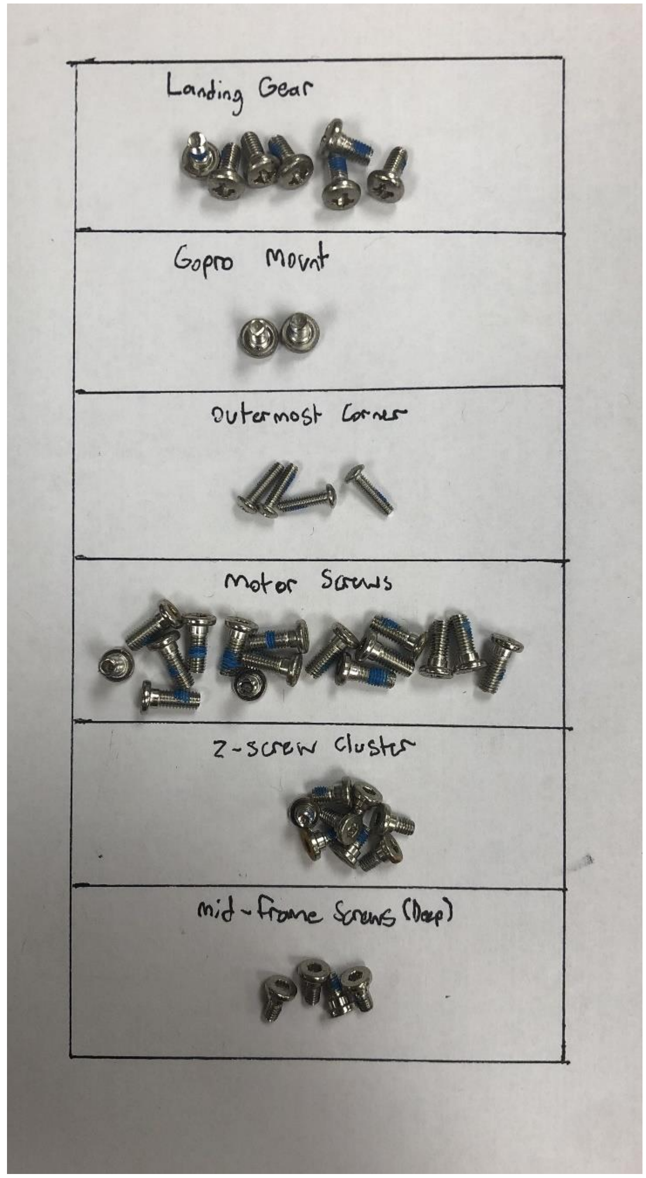


Figure 4. *To keep track of the screws for the reassembly process following this project, I labeled the removal sight of each screw.*

Disassembly Process

Figure 5. *First, I twisted off the propellers, each of which is uniquely specific. There are opposite front/back models along with duller versions for the rear.*

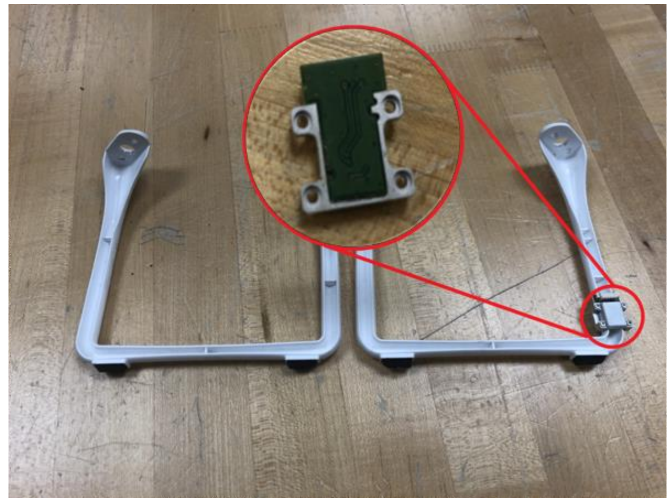


Figure 6. *I then removed the landing gear, which houses a component of the GPS: the compass module. It needs physical separation distance from the motor vibration.*

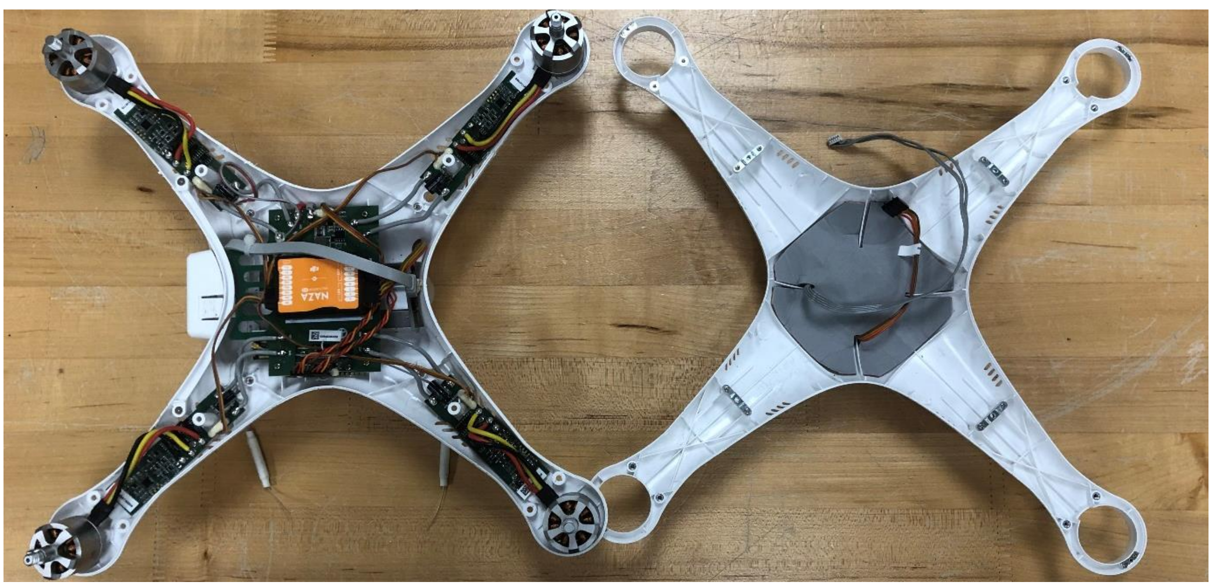


Figure 7. *After I removed the various screws from the drone case, I separated the top and bottom half to reveal the internal components.*

Electronics & Subsystems

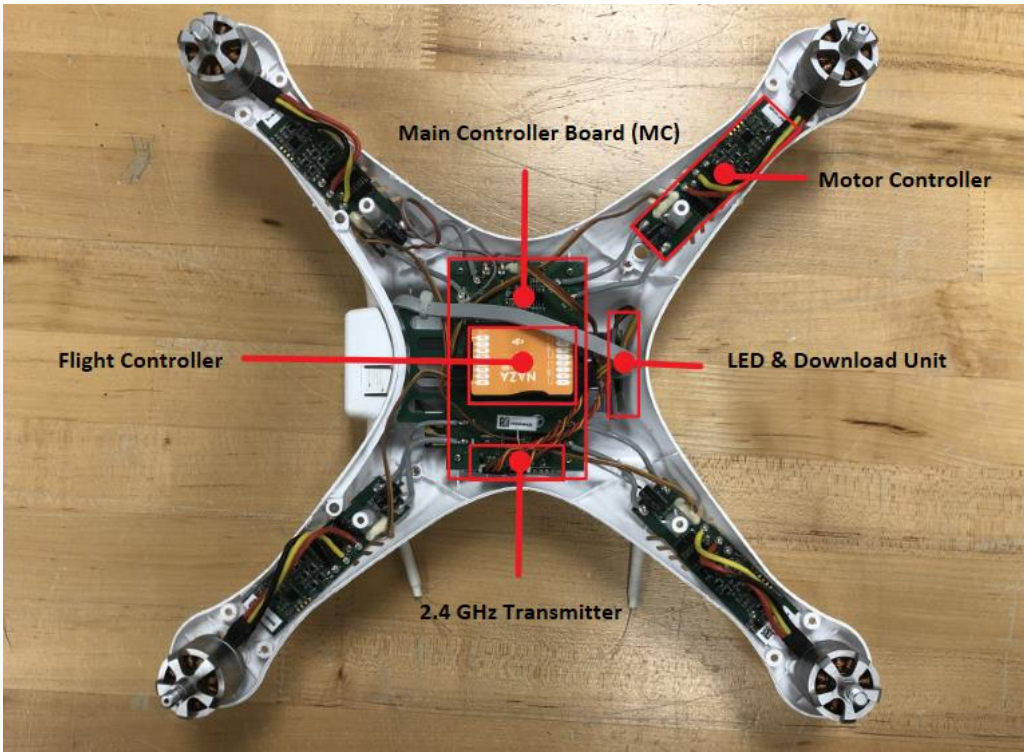


Figure 8. The subsystems branching from the main controller board are labeled here, which will be investigated further through the duration of the analysis and deconstruction.

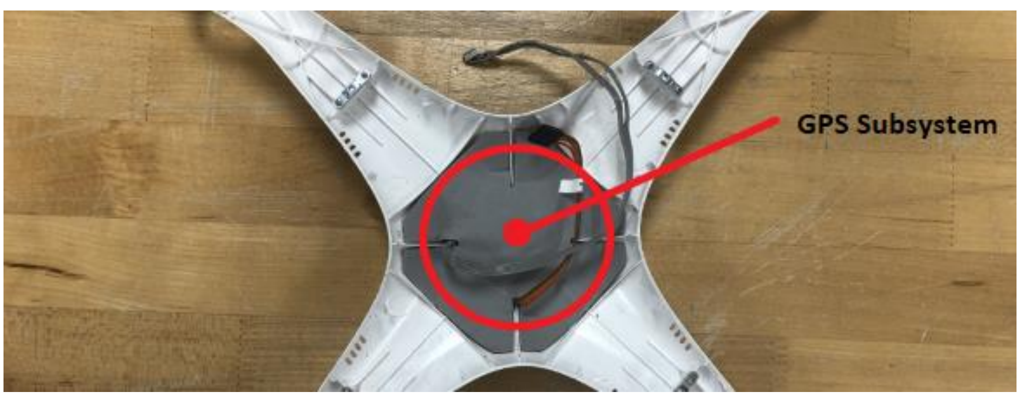


Figure 9. The only component linked to the top drone case is the GPS unit, which connects to the landing gear's compass module.

Main Controller

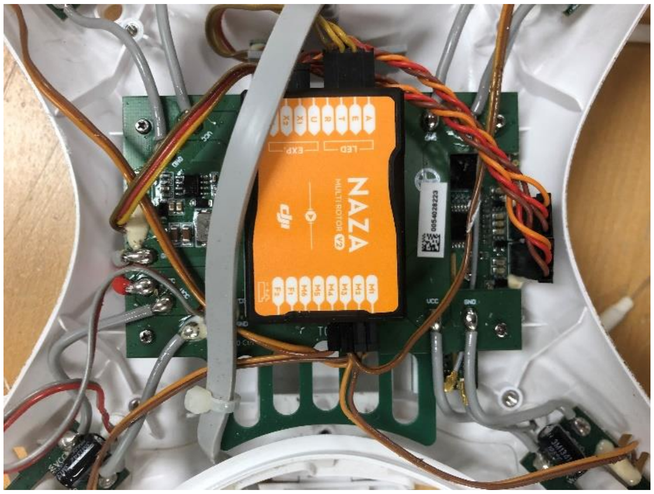


Figure 10. The main controller (MC) is the drone's central hub, similar to a computer's motherboard. It connects and directs everything to the NAZA V2.

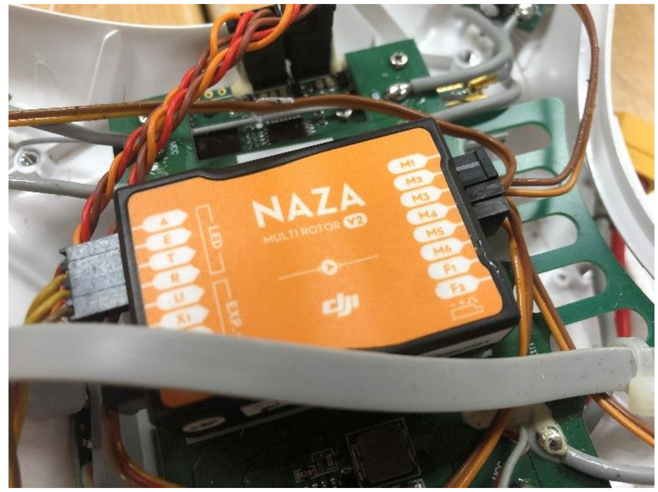


Figure 11. The NAZA V2 is essentially the flight controller of the board, which can be compared to a computer's CPU (central processing unit).

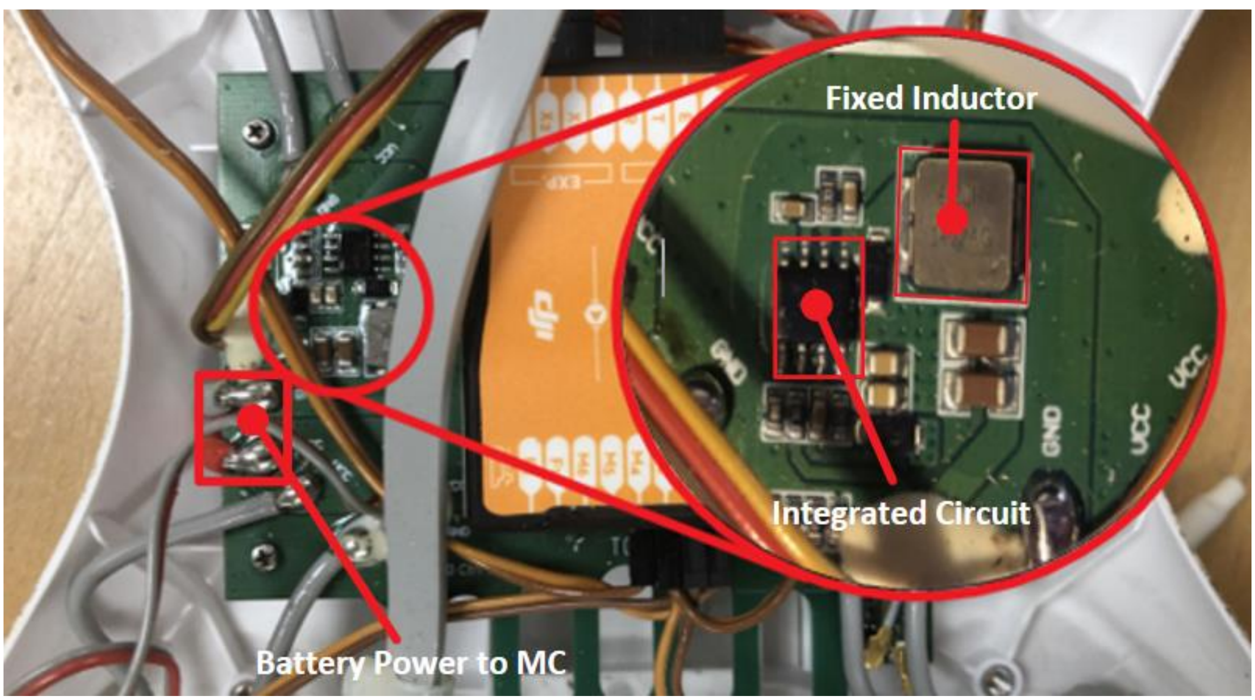


Figure 12. With little physical processing on the Main controller, it acts mainly as a power and connection hub. There appears to be power distribution control.

Global Positioning System

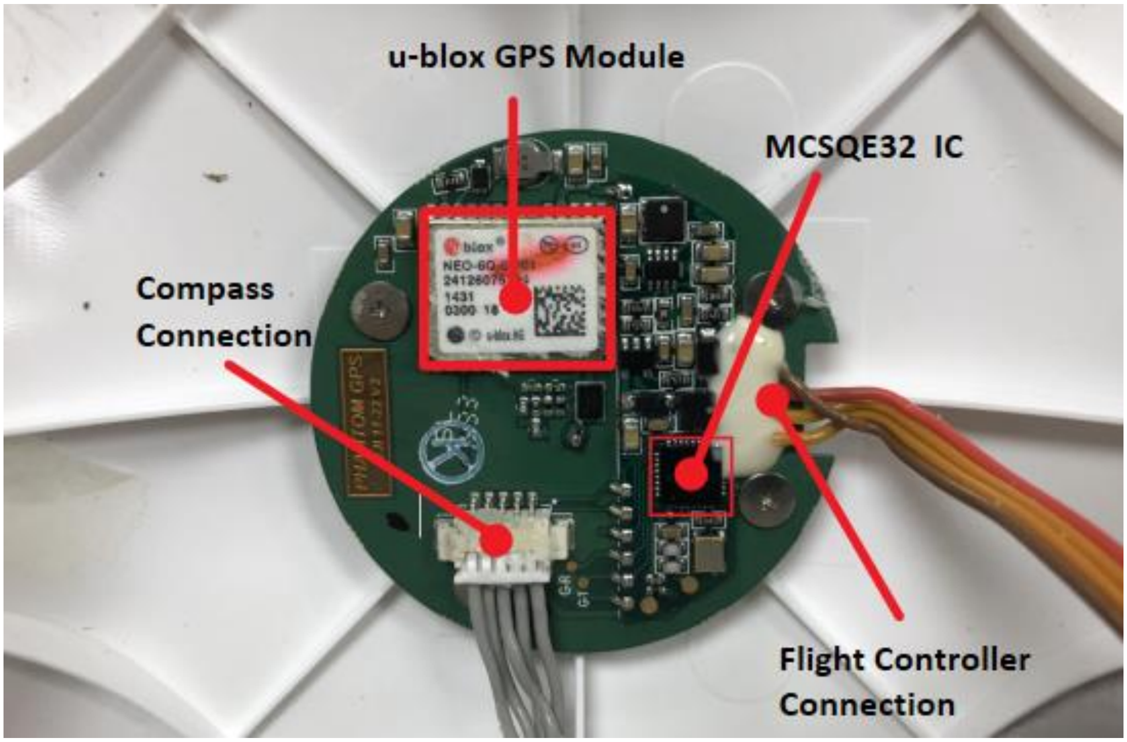


Figure 13. The GPS Unit integrates a controller and a u-blox GPS module to connect with satellites for stable flight control accurately.

LED Unit

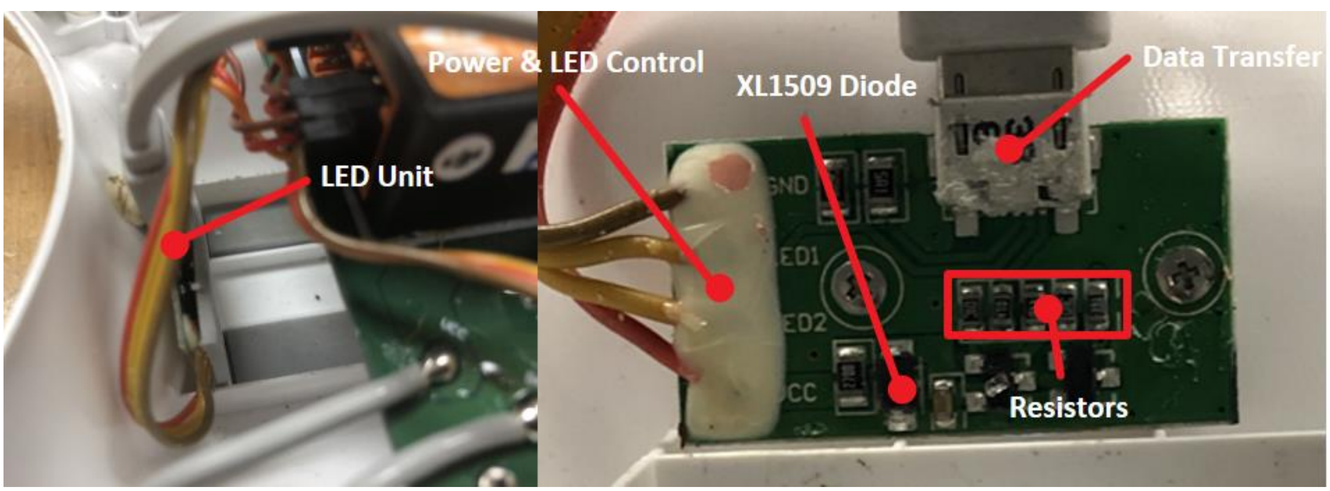


Figure 14 &15. The LED unit is hidden in the back-battery compartment and mainly serves as an indication LED and a download hub for updates.

2.4 GHz Transmitter

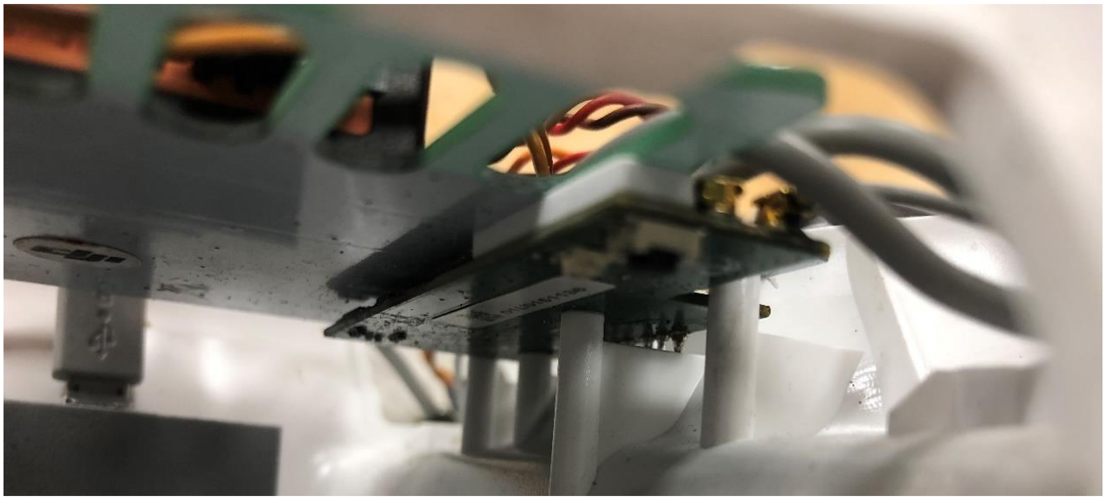


Figure 16. The 2.4 GHz transmitter is located beneath the MC board and establishes a connection between the remote control for wireless flight.

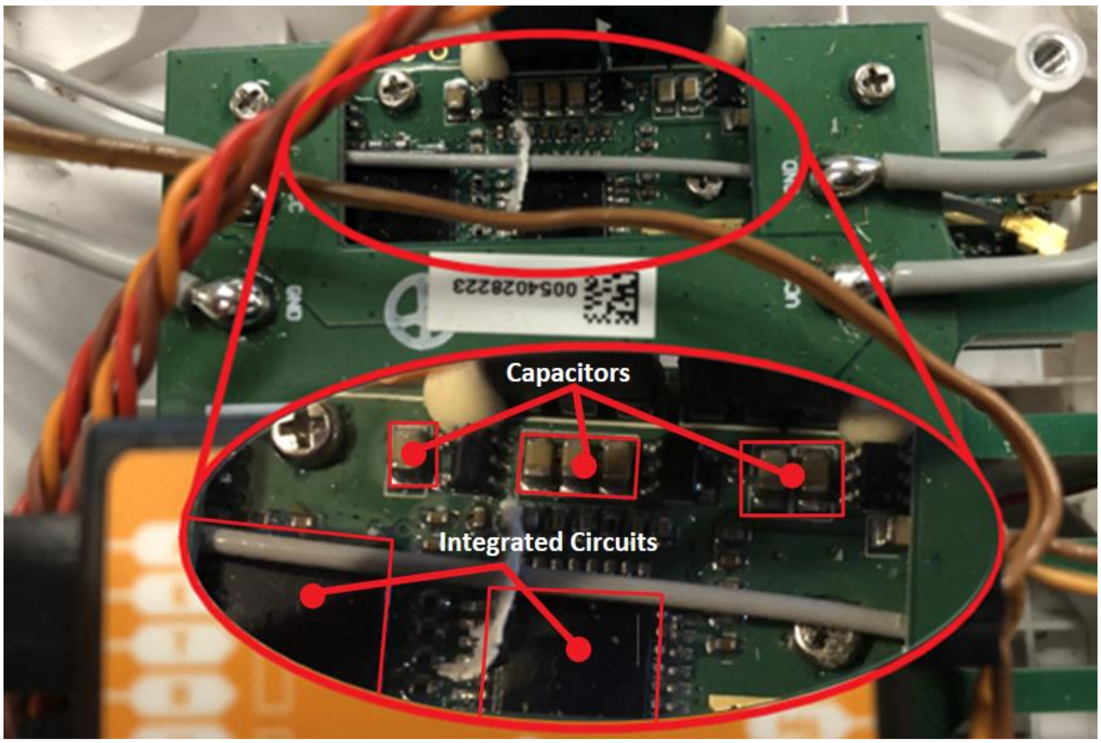


Figure 17. The top of the 2.4 GHz transmitter module reveals the unlabeled IC controllers, which likely process data collected from the antennas.

Propeller Subsystem

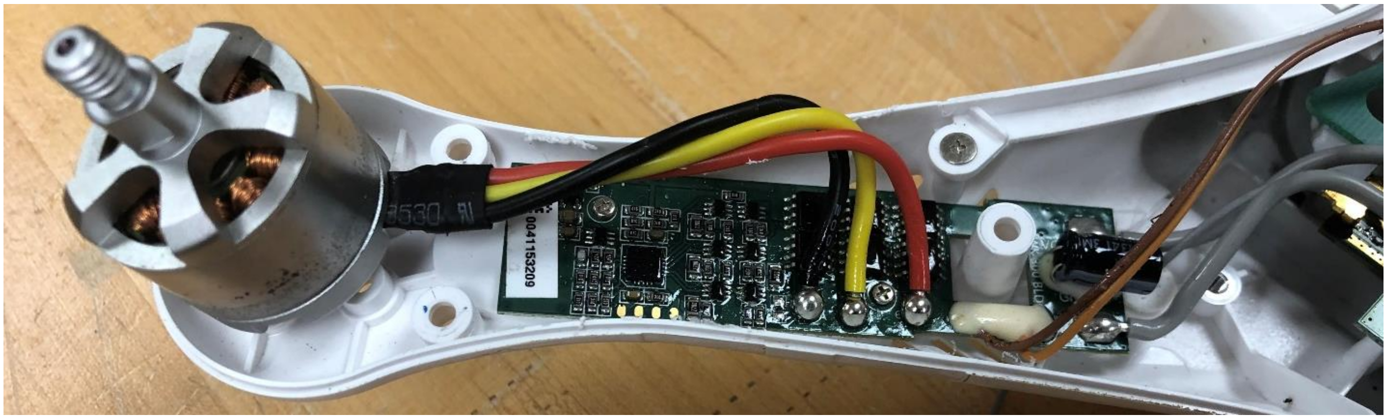


Figure 18. There are four identical motor/propeller subsystems, which consist of power delivery and a motor control system that converts power & data to motor output.

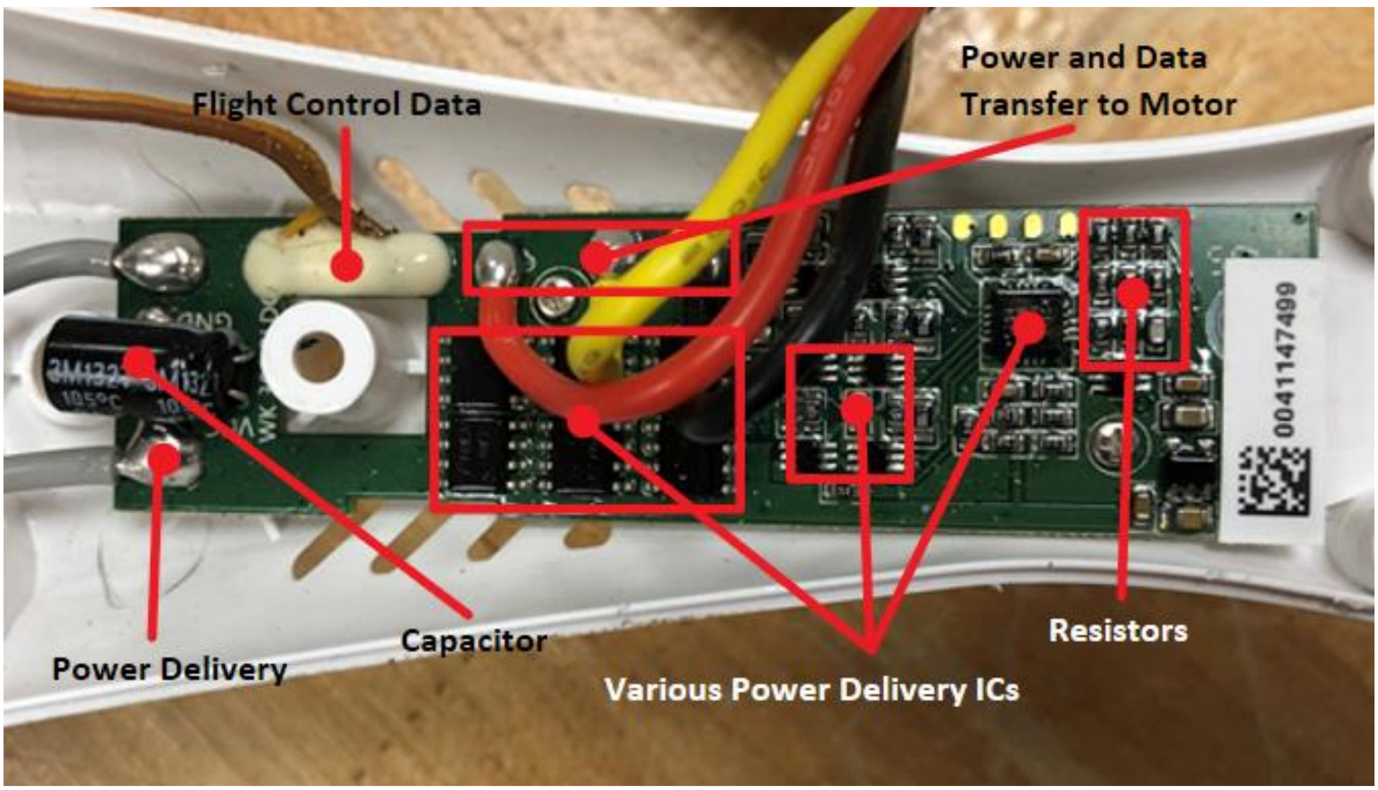
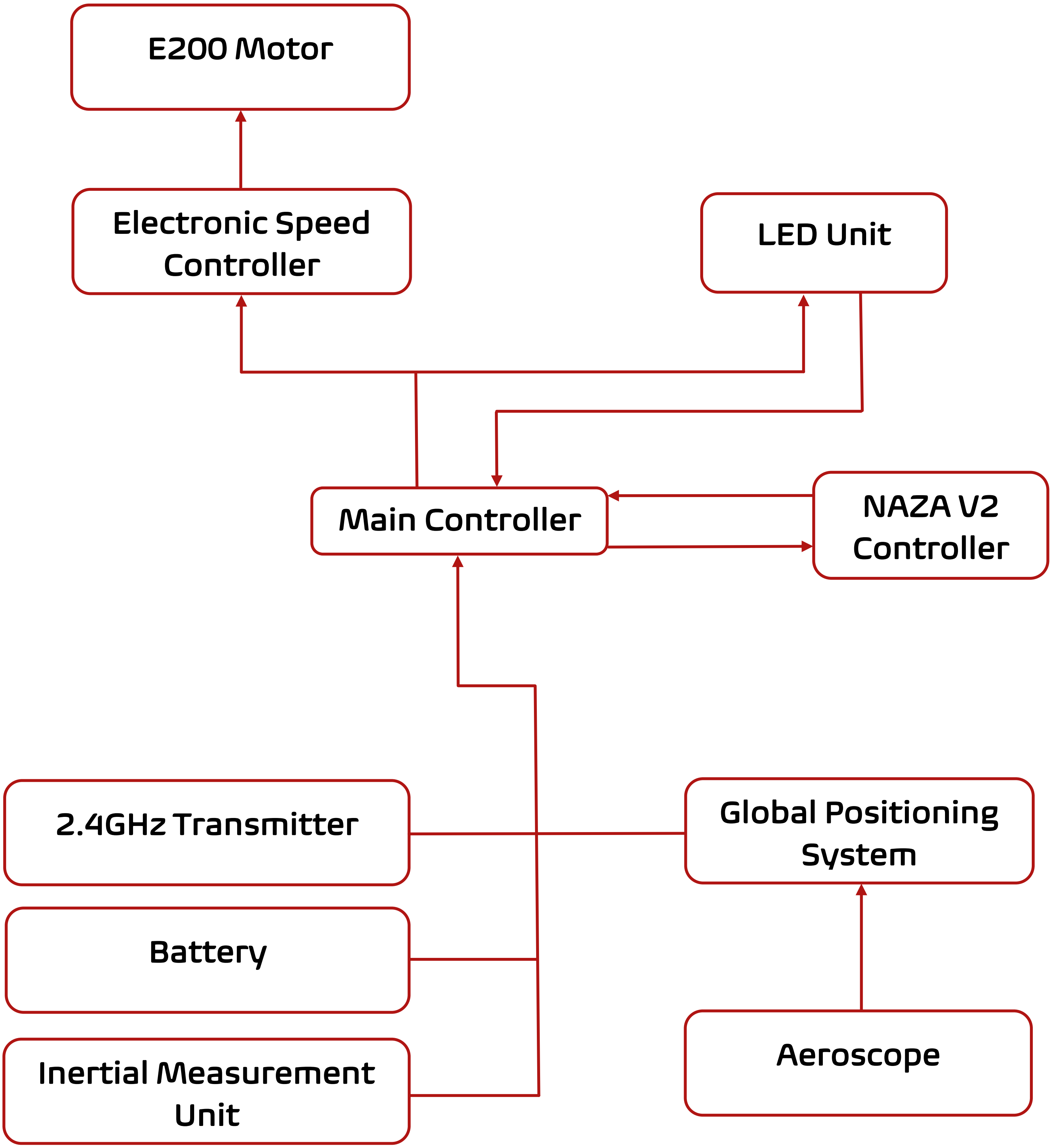


Figure 19. The motor control system takes flight control input and power to manage motor velocity. There is also a large capacitor to keep the current constant.

List of Components

Subsystem	Product	Manufacturer	Function	Datasheets
Main Controller (MC)	6.8uH Inductor	Bourns	Preserves low frequency voltage in a magnetic field to allow consistent current.	Datasheet
	S1x-13-f Diode	Diodes inc.	Directional flow of electricity exclusively. Not used for AC/DC conversion in this situation – Battery is DC.	Datasheet
	Inertial Measurement Unit (IMU)	InvenSense	Gives vital data such as acceleration and orientation. This allows for sustained flight via corrective measures from extrapolated data.	Datasheet
Flight Control Unit	NAZA v2 Flight Controller	DJI	Processes information collected from sensors and inputs to direct the electronic speed control units.	Datasheet
11.1-volt Battery	LIR18650	EEMB	Powers the MC which diverts power to the rest of the system passively.	Datasheet
2.4 GHz transmitter board	DNT24C Transceiver	muRata Co.	Uses a pass-band filter to collect specific controls from the remote and relay that information to the MC.	Datasheet
LED Unit	XL1509 150KHz DC converter	XKSEMI	Indicates error and connection status to the user and provides a gateway for updates.	Datasheet
GPS Module	NEO-6 u-blox 6 GPS	U-blox	The GPS unit that calculates relative position for range specific applications.	Datasheet
	Compass Module - Aeroscope	DJI	Noise-sensitive component that gathers flight states, UAV connection links, and other information in real time.	Datasheet
Electronic Speed Controller	3M132 Capacitor	Nippon Chemi-Con	Holds electric voltage between two plates to even out current and prevent sudden loss of power.	Datasheet
	E200 Motor	DJI	Controlled directly by the ESC to achieve sustained flight.	Datasheet

Subsystem Intricacies



Summary of Components

There is a complex integration of electronic subsystems in the Phantom 1 drone: all parts work in unison to keep the drone stable and controllable. The 11.1-volt power is directed from the battery, through the main controller, then to each of the electronic speed controllers (ESCs). Meanwhile, the flight control unit takes data from the GPS & compass system, 2.4 GHz transmitter, and motors to calculate adjustments. This complex interaction is quicker than a blink of the eye due to the integrated circuit controllers, thus allowing for real-time adjustments to a drone mid-flight. It is truly remarkable that gyroscopic measurements and taken, calculated, and then output to the motors occur instantaneously. Without these technological advancements, the capacity to continually correct the drone's flight would be unobtainable. The final component integration is the LED unit, which is non-essential during operation but takes care of transmitting data from the user's computer to the flight controller.

Specific Research

U-blox NEO-6 GPS

The NEO-6 is an i2c (a serial communication protocol) interface compatible GPS module. It takes advantage of a crystal oscillator and RTC (real-time clock) to achieve reliable and quick start times. Additionally, the crystal oscillator uses a vibrating crystal's mechanical resonance to achieve a constant frequency required for operation. The form factor is particularly small, and the power consumption is low, which makes it ideal for its application in the DJI Phantom 1 drone. The GPS model is essential for the drone's operation due to tracking and, most importantly, upright travel (otherwise, it will crash and break).

3M132 Capacitor

Although the capacitor does not perform any fancy calculations, it does have an integral aspect in the Phantom 1 drone's continual flight: it prevents the motors from seizing mid-flight. Capacitors are used on each of the ESC modules to hold spare current between two plates; this acts as a temporary power bank that keeps the flow of electricity consistent.

Conclusions

The research, which frankly is too much to include, has broadened my understanding of the interactions of components on PCBs (printed circuit boards). I discovered a lot regarding flight control, GPS control, and essential circuit components like capacitors, integrated circuits, diodes, transistors, RTCs, and crystal oscillators. One of the most interesting aspects of this challenge was the complex interactions I discovered between each daughterboard and its relation to modern technology.

Word Count: 494

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